alloys, are extremely malleable and ductile, can be worked either hot or cold, easily engraved, the higher grades have an elasticity exceeding steel, are easily cast into complicated objects, do not lose in remelting, and are possessed of great strength, dependent, of course, on the purity and percentage of contained aluminium. The 10 per cent. alloy, when cast, has a tensile strength of between 70,000 and 80,000 pounds per square inch, but when hammered or worked, the test exceeds 100,000 pounds. [A sample shown broke at 105,000 pounds.]

An attempt to enumerate either the present uses or the possible future commercial value of these alloys is beyond my present purpose. I may, however, remark that they are not only adapted to take the place of bronze, brass, and steel, but they so far surpass all of those metals, both physically and chemically, as to make their extended use assured. [Sheets, rods, tubes, wire, and ingots shown.]

But even a more important use of aluminium seems to be its employment in the iron industry, of which it promises shortly to become an important factor, owing to certain effects which it produces when present, even in the most minute proportions. Experiments are now being carried on at numerous iron and steel works, in England, on the Continent, and in America. The results so far attained are greatly at variance, for whilst in the majority of cases the improvements made have encouraged the continuance of the trials, in others the result has not been satisfactory. On this point I would wish to say to those who may contemplate making use of aluminium in this direction, that it would be advisable before trying their experiments to ascertain whether the aluminium alloy they may purchase actually contains any aluminium at all, for some of the so-called aluminium alloys contain little or no aluminium, and this may doubtless account for the negative results obtained. Again, others contain such varying proportions of carbon, silicon, and other impurities, as to render their use highly objectionable.

It seems to be a prevailing idea with some people, that, because aluminium is so light compared with iron, they cannot be directly alloyed, and, furthermore, that, for the same reason, alloys made by the direct melting together of the two metals would not be equal to an alloy where both metals are reduced together. Now, of course, this is not the case, and the statement has been put forward by those who were only able to make the alloys in one way.

Aluminium added to molten iron and steel lowers their melting-points, consequently increases the fluidity of the metal, and causes it to run easily into moulds and set there, without entrapping air and other gases, which serve to form blow-holes and similar imperfections. It is already used by a large number of steel founders, and seems to render the production of sound steel castings more certain and easy than is otherwise possible.

One of the most remarkable applications of the property which aluminium possesses of lowering the melting-point of iron has been made use of by Mr. Nordenfeldt in the production of castings of wrought iron.

Aluminium forms alloys with most other metals, and although each possesses peculiar properties which in the future may be utilized, at present they are but little used.

In conclusion, I beg to call your attention to the wood models on the table, one being representative of aluminium, the other aluminium bronze. The originals of these models are now in the Paris Exhibition, each weighing 1000 pounds. With regard to aluminium bronze, I cannot speak positively, but the block of pure aluminium is undoubtedly the largest casting ever made in this most wonderful metal. I have to thank the Directors of the Aluminium Company, and especially Mr. Castner, for furnishing me with the interesting series of specimens of raw and manufactured metal for illustrating my discourse.

THE PALÆONTOLOGY OF STURGEONS.[1]

THE palæontological history of the Acipenseroid fishes is at present very imperfectly known. In the existing fauna, only two families are recognizable—that of the Acipenseridæ, with series of bony dermal scutes upon the trunk, and that of Polyodontidæ, destitute of any such armour; both these occupy so low a position in the scale of organization, that considerable evidence of numerous extinct allies might naturally be expected to occur among the fossils of the older rocks. Such evidence, however, can as yet be only slightly recognized. Remains of typical members of the two existing families seem to occur as low in the Tertiary series as the Eocene formation. Pectoral spines and dermal scutes, indistinguishable from those of the living *Acipenser*, are met with in the Upper Eocene of the Hampshire Basin, and the London Clay (Lower Eocene) of the Isle of Sheppey; and Prof. E. D. Cope has described a fish (*Crossopholis*) from the Eocene Green River Shales of Wyoming, U.S.A., differing only from the typical Polyodontidæ in the possession of rudimentary scales upon the sides of the trunk.

The only Cretaceous fossils yet known, which are at all comparable with characteristic parts of the Acipenseroid skeleton, are two specimens from the English Chalk. The remains of a tail from Gravesend, in the British Museum, are most satisfactorily interpreted as belonging to a fish of this type; and the extremity of a snout from Sussex, in the Willett Collection, Brighton, seems to be more nearly paralleled by the snout of *Acipenser* than by that of any other known fish. Other fragmentary evidence of Acipenseroids in Upper Jurassic rocks will probably soon be recognized, thanks especially to the investigations of Mr. Alfred N. Leeds in the Oxford Clay of Peterborough; but the most complete and unmistakable fossils occur in the English Lower Jurassic—both in the Upper Lias of Whitby and the Lower Lias of Lyme Regis.

The gigantic Acipenseroid of Whitby was first noticed by Agassiz, under the name of *Gyrosteus mirabilis*, but it has not hitherto been scientifically investigated and described. The head seems to have been enveloped in few membrane bones, none externally ornamented or covered with ganoine; the chondrocranium is scarcely ossified; and the jaws are toothless. The opercular apparatus is incomplete, without branchiostegal rays; and the membrane bones of the pectoral arch are unornamented. There is evidence of a persistent notochord, and a few ossified ribs occur anteriorly. The upper lobe of the tail exhibits the characteristic series of large fulcra, and the trunk seems to have been naked.

Gyrosteus thus conforms to the normal Acipenseroid type as represented at the present day; but the genus of the Lower Lias, *Chondrosteus*, displays many striking differences. As pointed out especially by Dr. R. H. Traquair, these differences tend to place the fish half-way between the modern Sturgeons and the typically Palæozoic group of Palæoniscidæ. The roof of the skull exhibits definite frontal, parietal, squamosal, and supra-temporal membrane bones; in addition to the operculum and sub-operculum there are distinct branchiostegal rays; and in minor features there are several interesting resemblances to points of Palæoniscid osteology. Dr. Traquair, indeed, places the Palæoniscidæ in the "Acipenseroidei"; and it may be that, as no typical Acipenseroids of corresponding antiquity are known, the Sturgeons and Polyodons are the somewhat degenerate descendants of Palæozoic fishes upon this biological level. At the same time, it must be remembered that the Palæoniscidæ pass by several known gradations into the characteristic bony Ganoids of Mesozoic age; and if the ascertained facts of palæichthyology are already a sufficient basis for phylogenetic speculation, it thus appears that two diverging series arise from this primitive stock. In his latest classification (*American Naturalist*, 1887, p. 1018), Prof. Cope admits the origin of the later Ganoids from fishes of a Palæoniscid type; but, on the assumption that the basal cartilages (baseosts) of the pelvic fin in Palæoniscidæ were minute or absent, the Sturgeons are placed lower in the series than the latter. Under any circumstances, the relative development of a single structural feature is a slight point for the distinction of two "super-orders"; and if "Podopterygia" and "Actinopterygia" are to hold separate rank, the Palæoniscidæ (so far as all positive evidence is concerned) may be as justly placed in the former as in the latter.

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[1] Abstract of a Paper, by A. Smith Woodward, read before the Geologists' Association on January 4.

NITRATE OF SODA, AND THE NITRATE COUNTRY.

I.

TILL lately, nitrate of soda has only been known to the few who dealt in manures, or who were engaged in chemical manufactures; but within the last two years the British public have invested vast sums of money in the shares of Nitrate Companies, while the presence in society of live millionaires who have made their money in Tarapaca, and the strong personality of a "Nitrate King," have made "nitrates" a household word.

Deposits of nitrate of soda are known along the west coast of South America for a distance of 500 miles at least, from a little south of Taltal up to the River Camerones; and it is reported that beds have been discovered 150 miles further north, in the province of Arequipa (see Fig. 1).

The physical structure of the coast is identical throughout all that great length. Everywhere an arid range of hills 4000–6000 feet high rises abruptly out of the sea; while, behind them, a flat, waterless desert Pampa slopes gradually up for 50–100 miles to the foot of the snowy Cordillera. Nitrates are only found on this desert Pampa, but under somewhat variable conditions. On the Tamarugal Pampa—where all the great English companies have their factories—the nitrate is found exclusively on the western or seaward edge of the Pampa, on the first slopes of the coast-range; in the Noria district, on the lowest portion of a district surrounded by hills; and above Antofagasta on the sides of a dry river-bed.

The aspect of the Pampa is always essentially of the desert type. Above Iquique, the plain is sparsely covered with Tamarugal bushes; and the bold features of the Cordillera above Tarapaca form a sufficiently pleasing landscape. Inside from Antofagasta, on the desert of Atacama, there is no view of the mountains, and nothing greets the eye but a sloping plain of brown earthy sand, whose distant outlines can scarcely be distinguished through the quivering air. No cloud on the sky tempers the rays of a nearly vertical sun, blue mirage lakes tantalize the thirsty traveller, the hand can scarcely touch the scorching sand at 130°, the parched air may indicate 90°, and a light south-west wind raises whirlwinds of dust in every direction. Not a bird, nor a beast, nor a plant of the lowest type can live on these barren wastes; and yet the hidden wealth below has led to the erection of villages which contain more than 500 people, whose every necessary of life has to be brought from a great distance.

The absence of water has always been a great difficulty in the way of carrying on any industry in these deserts. Fifteen years ago, water sold on the Atacama desert for $20 the *arroba*—say 10*s.* a gallon—and a drink for a mule cost 15*s.* At Carmen Alto, in the same district, a sun condenser, with 50,000 square feet of glass, was employed to distil fresh from salt water; and though this was afterwards wrecked by a whirlwind, a smaller apparatus, on the same principle, is now working at a profit at Sierra Gorda, though the water is sold at only 30 cents. the *arroba*, or about $1\frac{1}{2}$*d.* a gallon.

Fresh water is now supplied to most of the towns on the coast, and to the factories inland, by means of condensed steam. Some of the condensers can produce no less than 25 tons of good water for every ton of coal burnt in the boilers; and some are even reported to have attained an efficiency of 30 tons of water for the same amount of fuel.

More recently, schemes have been started for the water supply of the towns on the coast by pipes from springs at the foot of the mountains beyond the Pampa; and Mollendo, Iquique, Antofagasta, and Taltal are either actually supplied with drinking-water by this means, or works are in progress for the same purpose.

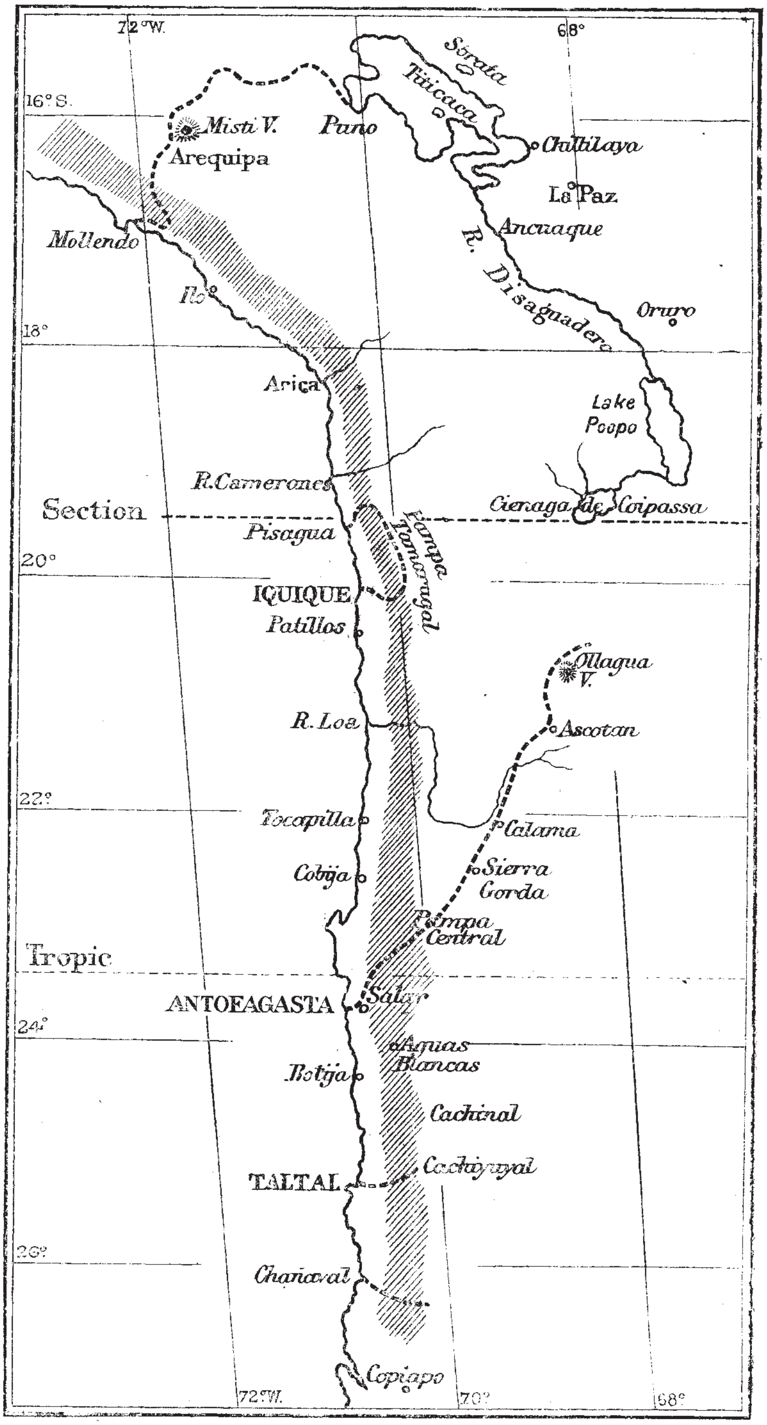

Fig. 1.—Map of the nitrate districts of South America. The shaded parts are nitrate grounds; but those north of the River Camerones are uncertain.

Very few Indians can have lived on the Pampa before the arrival of Europeans. A few Changos still survive along the seaward face of the coast range, who live by fishing, and who till recently had no knowledge of metals. The Aymara language is still spoken in Tarapaca, and all the place-names on the Tamarugal Pampa—such as Paccha, Jaz Pampa, Puntunchara, &c.—belong to that idiom. In the Antofagasta and Taltal districts, on the contrary, though further to the south, the place-names, such as Cachinal, &c., are Quichua, and any Indians of the Cordillera speak in that tongue. A good many of the *peons*, or labourers, who work in the *maquinas*, are Bolivians from Cochabamba, who talk Quichua, and some of the words used in the factories, such as *cancha*, &c., are derived from that language. These men chew *coca*, and though not so strong, are more laborious than the Chillenos from the south.

Passing from these generalities, we will now examine in more detail the structure and climate of the Tamarugal Pampa, between Iquique and Pisagua, in which most English people are interested. Fig. 2 is a diagrammatic section from the sea across the Cordillera, through the nitrate beds of Tarapaca. To the left we see the barren coast range rising from the sea and falling again to the level of the Tamarugal Pampa. The nitrate beds are marked in their proper place at the first spring of the hill; then comes the level Pampa, sloping gently not only from the Cordillera, but also slightly in a south-west direction. This slope is of course enormously exaggerated in the diagram.

Next the counterforts of the Sierra of Huatacondo rise abruptly above the plain. Here and there the barren slopes of these mountains are intersected by narrow valleys or *quebradas*, each of which carries down a small stream of water that is eventually lost in the sand of the Pampa. Artificial irrigation at the side of each affords sustenance for a very scanty population, and only one village is of sufficient importance to form anything approaching to a small town. This is the town of Tarapaca, in a valley of the same name, which gives its name to the province in which Iquique and the nitrate beds are situated.

A high cold upland, or Puna, some 20 miles across, separates the crests of the outer Sierra of Huatacondo from the rather higher range of the Cordillera Silillica, and then the mountains slope steeply down to the plateau of Bolivia, some 12,000 feet above the sea. None of the crests of the outer Sierra retain any snow on their summits during the summer months, but a few of the crests of the inner Cordillera are white throughout the year.

Allusion has been already made to the Tamarugal bushes which are found in places on the Pampa. These owe their existence to the floods, or *avenidas* as they are called locally, which every few years rush down from the Sierra, and run over the plain almost to the edge of the nitrate grounds. The soil of the Pampa is just what might have been expected under such circumstances, for the surface is not sharp sand, but really dry earth with a certain proportion of sandy particles, and only irrigation is required to turn the desert Pampa into a fertile plain. Below ground, numerous sections which have been made in sinking wells, show alternating layers of gravel, sand, mud, and as each series of layers represents the sequence of a single flood, it follows that the Pampa has been subject to periodical inundations for a very long period.

The labours of Signor Don Guillermo Billinghurst have made us acquainted both with the *régime* of underground waters on the Pampa, and with their chemical constitution. From his researches it appears that water is found almost anywhere under the Pampa, at depths varying from about 50 to 150 feet, but that nowhere are the conditions necessary for artesian wells fulfilled. The well water from the centre of the Pampa contains too great a proportion of salts to be considered drinkable; and that from the western margin of the plain, but not in the nitrate beds, belongs to the calcareo-magnesian class, which is totally unfit for domestic or culinary purposes. The following examples will make this very clear, and also the remarkable fact that *the underground waters of the Pampa do not contain the slightest trace either of nitrate of soda, or of iodine*, though they contain a greater proportion of mineral salts the further westward they run.

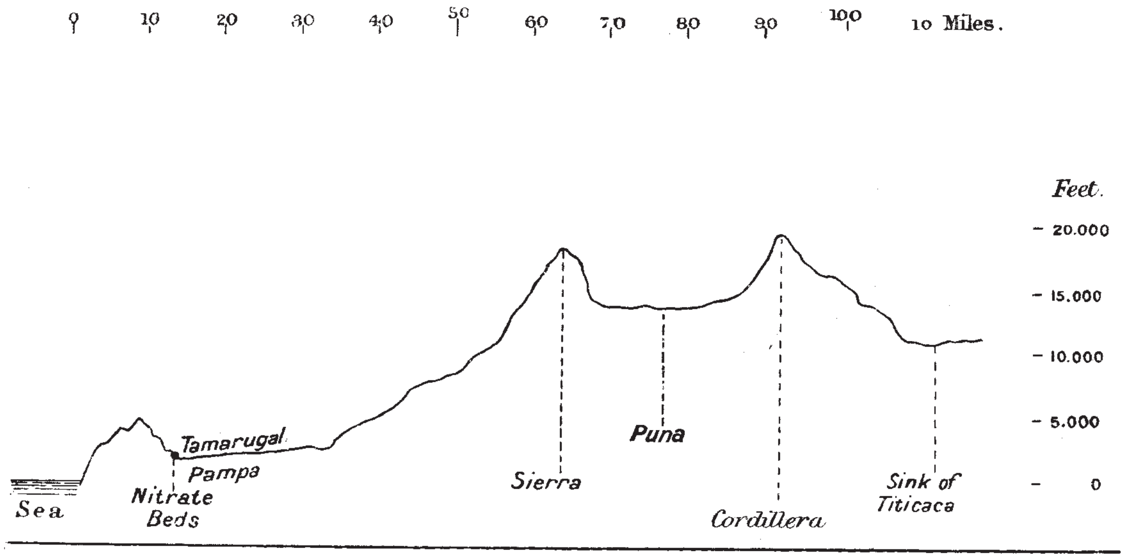

FIG. 2.—Section across the Cordillera, through the nitrate beds of Tarapaca.

The two subjoined analyses are those (1) of well water from Cerro Gordo, situated 7 miles from the nitrate beds, on the open plain of the Tamarugal Pampa; and (2) of the Pozo de Almonte, quite close to the nitrate beds, and from which a large proportion of the water used by the Nitrate Railway Company is derived—

	Cerro Gordo. Grammes per litre.	Pozo de Almonte. Grammes per litre.
Carbonate of lime	0·01500 ...	0·2499
,, magnesia ...	0·00300 ...	0·0323
Sulphate of lime	0·12920 ...	0·9843
,, magnesia	0·08166 ...	—
,, potash	0·00860 ...	—
,, soda	0·18062 ...	0·0735
Chloride of sodium	0·62261 ...	1·5799
,, magnesium ...	— ...	0·1737
Oxide of iron and alumina ...	0·01000 ...	—
Silica, and insolubles	0·00500 ...	0·0200
	1·05569	3·1136

In connection with underground waters we may as well dispel for ever the fiction so commonly believed that some of the overflow from Lake Titicaca filters under the Cordillera and reappears on the Tamarugal Pampa. This idea was started in a pre-scientific age, more than 300 years ago, in 1550, by the celebrated historian Cieza de Leon ("La Cronica del Peru," p. 445); but unfortunately for such a supposition the facts of the case are as follows. The only outlet of Lake Titicaca is the River Disaguadero (Span. drain), and the water at starting contains about 1 gramme of salts in every litre. By the time the river has reached the shallow lake of Poopo or Aullagas (see map, Fig. 1), the water is so salt as to be undrinkable, and then the river runs out for a short distance till it is finally lost in the salt mud marsh, or Ciénaga de Coipasa. No doubt this marsh is due east of the Pampa near Pisagua, and is marked "Sink of Titicaca" in Fig. 1; but still it is impossible to believe that salt water can come out fresh on the other side of the Cordillera. The water of the Tamarugal Pampa must be derived from the rainfall on the slopes of the Sierra, immediately above the plain.

RALPH ABERCROMBY.

(*To be continued.*)